

**SECTION 03300
CAST-IN-PLACE CONCRETE**

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to this section.

1.2 SUMMARY

- A. Scope: Provide labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for cast-in-place concrete as required for the complete performance of the work, and as shown on the drawings and as herein specified.
- B. Section Includes: Provide cast-in-place concrete work including, but not limited to, installation of anchor bolts and embedded steel and related items as shown on the drawings and specified herein. Coordinate size and location of equipment bases with Division 15 - Mechanical and Division 16 - Electrical.
- C. Related Sections: The following sections contain requirements that relate to this section:
 - 1. Division 3 Section 03331 "Architectural Cast-In-Place Concrete" for architectural concrete and finishes.
 - 2. Division 5 Section 05120 "Structural Steel" for anchor bolts and embedments.

1.3 REFERENCES

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.
- B. The edition/revision of the referenced publications shall be the latest date as of the date of the Contract Documents, unless otherwise specified.
- C. American Concrete Institute (ACI):
 - 1. ACI 117 "Standard Specifications for Tolerances for Concrete"
 - 2. ACI 211.1 "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete".
 - 3. ACI 211.2 "Standard Practice for Selecting Proportions for Structural Lightweight Concrete" (copyrighted by ACI, ANSI approved).
 - 4. ACI 214 "Recommended Practice for Evaluation of Strength Test Results of Concrete".
 - 5. ACI 301 "Specifications for Structural Concrete for Building"
 - 6. ACI 302.1R "Guide for Concrete Floor and Slab Construction"
 - 7. ACI 304R "Guide for Measuring, Mixing, Transporting, and Placing Concrete".
 - 8. ACI 305R "Hot Weather Concreting".
 - 9. ACI 306R "Cold Weather Concreting".
 - 10. ACI 308 "Standard Practice for Curing Concrete"
 - 11. ACI 311.1R "ACI Manual of Concrete Inspection".
 - 12. ACI 311.4R "Guide for Concrete Inspection".
 - 13. ACI 315 "Details and Detailing of Concrete Reinforcement".
 - 14. ACI 318 "Building Code Requirements for Reinforced Concrete".
 - 15. ACI 347 "Formwork for Concrete".
 - 16. ACI SP-66 "ACI Detailing Manual".

- D. American Welding Society (AWS):
 - 1. AWS D1.4 "Structural Welding Code - Reinforcing Steel" (copyrighted by AWS, ANSI approved).
- E. ASTM (ASTM):
 - 1. ASTM A 185 "Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement".
 - 2. ASTM A 615 "Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement".
 - 3. ASTM A 675 "Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
 - 4. ASTM A 775 "Standard Specification for Epoxy-Coated Reinforcing Steel Bars".
 - 5. ASTM A 955M "Standard Specification for Deformed and Plain Stainless Steel Bars for Concrete Reinforcement (Metric)"
 - 6. ASTM C 31 "Standard Practice for Making and Curing Concrete Test Specimens in the Field".
 - 7. ASTM C 33 "Standard Specification for Concrete Aggregates".
 - 8. ASTM C 39 "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens".
 - 9. ASTM C 42 "Standard Test Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete".
 - 10. ASTM C 94 "Standard Specification for Ready-Mixed Concrete".
 - 11. ASTM C 143 "Standard Test Method for Slump of Hydraulic Cement Concrete".
 - 12. ASTM C 150 "Standard Specification for Portland Cement".
 - 13. ASTM C 171 "Standard Specification for Sheet Materials for Curing Concrete".
 - 14. ASTM C 172 "Standard Method for Sampling Freshly Mixed Concrete".
 - 15. ASTM C 173 "Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method".
 - 16. ASTM C 231 "Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method".
 - 17. ASTM C 260 "Standard Specification for Air-Entraining Admixtures for Concrete".
 - 18. ASTM C 309 "Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete".
 - 19. ASTM C 330 "Standard Specification for Lightweight Aggregates for Structural Concrete".
 - 20. ASTM C 494 "Standard Specification for Chemical Admixtures for Concrete"
 - 21. ASTM C 618 "Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete".
 - 22. ASTM C 881 "Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
 - 23. ASTM C 1017 "Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete"
 - 24. ASTM D 1751 "Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)".
 - 25. ASTM D 2103 "Standard Specification for Polyethylene Film and Sheet".
 - 26. ASTM E 329 "Standard Practice for Use in the Evaluation of Testing and Inspection Agencies as Used in Construction".
 - 27. ASTM E 154 "Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover".
 - 28. ASTM E 1155 "Standard Test Method for Determining Floor Flatness and Levelness Using the F-Number System".
- F. Concrete Reinforcing Steel Institute (CRSI):
 - 1. CRSI MSP "Manual of Standard Practice".
- G. National Ready Mixed Concrete Association (NRMCA):

1. NRMCA QC-3 "Checklist for Certification of Ready Mixed Concrete Production Facilities".

1.4 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of the Contract and General and Supplementary Conditions general requirements.
- B. Product Data: Submit product data including, but not limited to, manufacturer's specifications, technical product data for each item, installation instructions, catalogue cuts, and other information necessary to show compliance with requirements. Products for which data is required shall include, but shall not be limited to, the following:
 1. Coating material.
 2. Surface treatment material.
 3. Joint sealer.
 4. Vapor barrier.
 5. Waterstops & Water Swelling Strips
 6. Admixtures.
 7. Anchors.
 8. Bonding materials.
 9. Curing compounds
 10. Formwork surface materials.
- C. Shop Drawings for Reinforcing: Submit shop drawings for reinforcement. Comply with ACI SP-66, showing bar schedules, stirrup spacing, diagrams of bent bars, and arrangement of concrete reinforcement. Shop drawings shall be submitted in sufficient time for review and, if necessary, resubmittal, plus a time allowance for fabrication and delivery of steel. Plans shall be at no less than 1/8 inch equals 1 foot (1:96), and wall and beam elevations shall be at no less than 1/4 inch equals 1 foot (1:48).
 1. Shop drawings shall show the locations and detailing of all splices, construction joints, curbs, slab depressions and support bars.
 2. Shop drawings shall include a bill of material and weights for each sheet.
- D. Formwork Certificate: Supplier shall submit a letter certifying that the formwork has been designed in accordance with the project drawings and specifications by a qualified Professional Engineer in the State of Tennessee.
- E. Reinforcing Steel Certificate: Supplier shall submit certification that the reinforcing steel bars meet the project requirements.
- F. Design Mix: The Concrete Contractor shall submit proposed design mix as prepared by the Contractor's testing agency or with historical data from the production facility producing the mix.
- G. Contractor's Testing Agency: Submit written request for acceptance of the Contractor's testing agency, qualified per ACI requirements to design concrete mixes, and provide evidence of inspection, within past 12 months, of its facilities by the Cement and Concrete Reference Laboratory of the National Bureau of Standards. Also show that deficiencies mentioned in the report of that inspection have been corrected. Submit certified documentation that the scales have been calibrated within the past 12 months. Testing Agency shall be qualified for testing floor flatness and levelness in accordance with ASTM E 1155.
- H. Material Data: Contractor shall submit requests for acceptance of proposed materials, which shall include, but shall not be limited to, the following:
 1. Aggregates.
 2. Fly ash.
 3. Admixtures.

4. Cement.
 5. Water.
- I. Test Reports and Certificates of Compliance: Contractor shall submit test reports and certificates of compliance from the Contractor's testing agency for proposed materials in the design mixes and the designs mixes.
1. Certify that the design mixes meet this project's Contract Documents.
 2. Certify that the materials to be used in the mixes meet the indicated ASTM and Contract Document requirements.
- J. Delivery Tickets: Concrete Unit Price Supplier Contractor shall submit samples of ready-mixed concrete delivery tickets in accordance with the requirements of ASTM C 94.
- K. Written Procedures: Contractor shall submit written procedures for:
1. Controlling concrete temperature during hot weather.
 2. Cleaning joints.
 3. Repair of concrete. Repair of surface defects shall be in accordance with paragraph 3.11. Procedures which require removal of concrete shall be submitted 15 days before making the repairs.

1.5 QUALITY ASSURANCE

- A. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.
- B. Codes and Standards:
1. The following specifications and codes shall govern concrete and concrete work, unless otherwise modified herein:
 - a. ACI 117
 - b. ACI 301.
 - c. ACI 304R
 - d. ACI 304.3R.
 - e. ACI 311.1R.
 - f. ACI 311.4R.
 - g. ACI 318.
 - h. ACI 347.
 - i. CRSI MSP.
 2. The Contractor shall have available in the field office a copy of ACI SP-15 containing ACI 301, with selected ACI and ASTM references.
- C. Qualify welding procedures and welding operators in accordance with AWS qualification requirements.
1. Provide certification that welders to be employed in work have satisfactorily passed AWS qualification tests within the last six months.
 2. If recertification of welders is required, retesting shall be the Contractor's responsibility.
 3. Welding procedures must be approved as prequalified or qualified for this project.
- D. Review structural steel and metal deck surveys required per Section 05120 - Structural Steel. Determine the necessary screeding, strike off, placement, and finishing requirements and procedures to produce surfaces meeting specified tolerances relative to surveyed conditions.

PART 2 - PRODUCTS

2.1 FORM MATERIALS

- A. Forms for Exposed Finish Concrete: Provide plywood, metal, metal-framed plywood-faced, or other acceptable panel-type materials, to provide continuous, straight, smooth, exposed surfaces. Furnish in largest practicable sizes to minimize number of joints and to conform to joint system shown on the drawings.
- B. Forms for Unexposed Finish Concrete: Provide plywood, lumber, metal, or other acceptable material. Provide lumber dressed on at least two edges and one side for tight fit.
- C. Form Coatings: Provide commercial formulation form coating compounds with a maximum volatile organic compounds (VOC's) of 350 g/L, that shall not bond with, stain, or adversely affect concrete surfaces and shall not impair subsequent treatments of concrete surfaces.
- D. Form Ties: Provide factory-fabricated, adjustable length, removable or snap-off metal form ties, designed to prevent form deflection and to prevent spalling concrete upon removal. Provide units that shall leave no metal closer than 1-1/2 inches to exposed surface. In locations where stainless steel reinforcing is used, form ties shall be stainless steel or suitable non-magnetic material.

2.2 CONCRETE MATERIALS

- A. Cement: Provide portland cement, Type I, or Type II, as indicated on the drawings, conforming to ASTM C 150, unless otherwise noted. Cement used in the work shall correspond to that upon which the selection of concrete proportions was based.
 - 1. Only a single brand and manufacturer of acceptable cement shall be used for exposed concrete.
 - 2. Type III cement shall be used only with prior review by the Construction Manager.
 - 3. Portland blast furnace slag cement and portland-pozzolan cement are prohibited.
- B. Aggregates: Aggregates shall conform to ASTM C 33. Local aggregates not complying with this standard may be used providing it can be shown by special test or a record of past performance that these aggregates produce concrete of adequate strength and durability.
 - 1. Fine aggregate shall be clean, sharp, natural sand, manufactured sand of a combination thereof. Aggregate shall be free from loam, clay lumps, or other deleterious substances, within allowable standards.
 - 2. Coarse aggregate shall be clean, uncoated, graded aggregate containing no clay, mud, loam, or foreign matter.
 - 3. Lightweight aggregates shall conform to ASTM C 330.
- C. Water: Water shall be drinkable.
- D. Admixtures: Provide admixtures produced and serviced by established reputable manufacturers and used in compliance with manufacturer's recommendations.
 - 1. Air-entraining admixture shall conform to ASTM C 260.
 - a. Provide certification attesting to compliance with ASTM C 260 shall be furnished by the manufacturer.
 - 2. Water-reducing, set-controlling admixture shall conform to ASTM C 494, Type A (water-reducing), Type C (accelerating admixture), Type D (water-reducing and retarding), Type E (water-reducing and accelerating), and Type F or Type G (water-reducing and super plasticizer).
 - a. A qualified concrete technician employed by the manufacturer shall be available to assist in proportioning concrete materials for optimum use and to advise on proper use of the admixture and adjustment of concrete mix proportions to meet job site and climatic conditions.
 - 3. Fly ash shall conform to ASTM C 618, Type C .or Type F.

4. The use of calcium chloride as an admixture is prohibited. Natural cement and slag cement shall not be used in admixtures.

2.3 METAL REINFORCEMENT

- A. Reinforcing Steel: Reinforcing steel shall conform to ASTM A 615, Grade 60, unless noted otherwise.
- B. Epoxy-Coated Reinforcing Steel: Comply with ASTM A 775.
- C. Welded Wire Fabric: Welded wire fabric shall conform to ASTM A 185. Sizes shall be as shown on the drawings or as required, but not less than 6 x 6 - W2.1 x W2.1.
- D. Axle Steel: Axle steel shall not be used.

2.4 EXPANSION JOINT DOWELS

- A. Expansion joint dowels shall be smooth steel conforming to ASTM A675, Grade 70. Dowels shall be straight and clean, free of loose flaky rust and loose scale. Dowels may be sheared to length provided deformation from true shape caused by shearing does not exceed 0.04 in on the diameter of the dowel and extends no more than 0.04 in from the end. Bars shall be coated with a bond breaker on the expansion end of the dowel. Expansion caps shall be provided on the expansion end. Caps shall allow for at least 1.5 inches of expansion.

2.5 MECHANICAL COUPLERS

- A. Mechanical couplers shall be provided where shown on the Drawings. Provide manufacturer's certification that the couplers shall develop a tensile strength which exceeds 125 percent of the yield strength of the reinforcement bar being spliced at each splice. Provide physical checkout of each coupler for damage before installation. Inspection after installation shall verify staggering of splices.

2.6 METAL AND CONCRETE ACCESSORIES

- A. Metal accessories shall conform to the requirements of CRSI MSP.
 1. Chairs, bolsters, spacers shall be galvanized after fabrication. Chairs and bolsters which are in contact with concrete surfaces to be exposed or painted shall, in addition, have plastic tips, or shall be fabricated of stainless steel.
 2. Tie wires and bar supports for epoxy-coated reinforcing shall be epoxy-coated or plastic-coated.
 3. Tie wires and bar supports for stainless steel reinforcing shall be austenitic stainless steel or other suitable non-magnetic material.
 4. Bar supports in contact with the ground shall be supported on precast concrete bar supports. Concrete blocks shall have a compressive strength of 4,000 psi. Brick may be used as an alternate for the 4000 psi concrete bar supports in contact with the ground, provided the bricks are clean, sound and free of deleterious material. Bricks shall be properly tied to the reinforcement and set to insure that the proper concrete cover is provided between the reinforcement and the ground below.

2.7 PREMOLDED JOINT FILLER

- A. Premolded joint filler shall conform to ASTM D 1751(fiber type).

2.8 CURING MATERIALS

- A. Cure and Sealer: Curing materials shall meet the requirements of ASTM C 309 and shall be compatible with subsequent floor finish applications. Provide for curing, sealing, and dustproofing for floors that are to remain exposed.
 - 1. Product: Subject to compliance with requirements, provide one of the following products for exposed interior concrete floors to cure, seal and dustproof:
 - a. "Super Rez-Seal", Euclid Chemical
 - b. "Day-Chem Cure and Seal (J-23)", Dayton Superior
 - c. "Dress and Seal 30", L&M Chemicals
- B. Cure and Hardener: Compound shall be a sodium silicate type and suitable for surface application to harden, seal and dustproof concrete. Cure concrete for 7 days with polyethylene sheet before applying compound.
 - 1. Product: Subject to compliance with requirements, provide one of the following products for exposed interior concrete floors to seal and harden:
 - a. "Eucosil", Euclid
 - b. "Cure Hard", W.R. Meadows
 - c. "Day-Chem Sil Cure (J-13)", Dayton Superior
 - d. "Chem Hard", L&M Chemicals

2.9 WATERSTOPS

- A. Waterstops shall be of polyvinyl chloride, and shall be 3/16 inch by 6 inch serrated, unless otherwise noted on the drawings. Joints for crosses, tees and "L's" shall be factory made using thermostatically controlled electric heat source.
- B. Water swelling strip shall be at least 3/4 inch by 3/8 inch flexible stripping made of rubber chemically bound with a hydrophilic polymer that swells to 1.9 times its original volume in the presence of water and returns to the original size when dry. The swelling stripping formulation shall delay swelling for at least 12 hours after contact with water, in order to avoid swelling when the concrete is placed. Provide manufacturer's recommended fasteners, adhesive and water swelling caulk.

2.10 VAPOR RETARDER

- A. Vapor retarder: ASTM E 1745, Class B, five-ply, nylon or polyester-cord reinforced, high-density polyethylene sheet; 10 mils (0.25 mm) thick.
 - 1. Available Product: Subject to compliance with requirements, a product that may be incorporated into the Work includes, but is not limited to, "Griffolyn T85" by Reef Industries Inc. complete with pipe boots for conduit and piping penetrations thru the vapor retarder.

2.11 FORM RELEASE AGENT

- A. Form release agent shall be a chemically reactive material which shall not stain or cause imperfections on the concrete surface and which shall be compatible with the finish surface treatment.

2.12 JOINT SEALER

- A. Joint sealer material shall be as specified in "Division 7 – Joint Sealants".

2.13 ANCHORS

- A. Chemical anchors shall be adhesive or epoxy type, using stainless steel components.
 - 1. Product: Subject to compliance with requirements, provide one of the following products:
 - a. "Hilti C-100 Adhesive", Hilti Fastening Systems
 - b. "Epcon System", ITW Ramset/Red Head
 - c. "Foil-Fast Cartridge System", Rawlplug Co., Inc.
- B. Concrete anchors shall be wedge type, made of stainless steel.
 - 1. Product: Subject to compliance with requirements, provide one of the following products:
 - a. "Kwik Bolt II", Hilti Fastening Systems
 - b. "Trubolt", ITW Ramset/Red Head
 - c. "Rawl-Stud", Rawlplug Co., Inc.

2.14 BONDING MATERIALS

- A. Epoxy Adhesive: Comply with ASTM C 881, two-component material suitable for use on dry or damp surfaces. Provide material type, grade, and class to suit Project requirements.
 - 1. Product: Subject to compliance with requirements, provide one of the following products:
 - a. "Euco Epoxy Systems #452 or #620", Euclid Chemical Co.
 - b. "Concresive (LPL)", Master Builders, Inc.
 - c. "Sikadur 32 Hi-Mod", Sika Corp.

2.15 CONCRETE INSERTS

- A. Materials: Concrete inserts shall be manufactured from 12 Gage steel channel sections conforming to ASTM A570 GR 33 or ASTM A653 GR 33 and shall be hot-dipped galvanized in conformance with ASTM A123 or A153.
 - 1. All inserts shall include closure and end caps to inhibit concrete see page as per manufactures specifications.
 - 2. Spacing between insert anchors and maximum distance between attachments to formwork shall be in accordance with the manufacturer's recommendations.
 - 3. Insert capacity shall be 2000 lbs/linear foot.
 - 4. Maximum depth into the concrete shall be 2 7/8".
- B. Locations: Concrete inserts shall be provided at locations indicated on the Contract Drawings.
- C. Manufacturer/Product: Concrete inserts shall be Unistrut Standard Duty Concrete Inserts P3253 through P3270 or approved equal.

2.16 SOURCE QUALITY CONTROL

- A. General: Materials and fabrication procedures are subject to inspection and tests in plant, shop, and field, conducted by a qualified inspection agency. Such inspections and tests shall not relieve the Contractor of responsibility for providing materials and fabrication procedures in compliance with specified requirements.
 - 1. Promptly remove and replace materials or fabricated components that do not comply.
- B. Design of Members and Connections: Details shown are typical, similar details apply to similar conditions, unless otherwise indicated. Verify dimensions at site whenever possible without causing delay in the work.
 - 1. Promptly notify the Construction Manager whenever design of members and connections for any portion of structure are not clearly indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions under which the work is to be installed, and notify the Construction Manager, in writing, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

3.2 SELECTION OF PROPORTIONS

- A. General: Concrete shall be composed of cement, fine aggregate, coarse aggregate, water, admixture, and, when specified, an air-entraining admixture. Proportions of ingredients shall produce concrete which shall work readily into corners and angles of forms and bond to reinforcement without segregation or excessive bleed water forming on the surface.
1. Proportioning of materials shall be in accordance with ACI 211.1 and ACI 211.2.
 - a. Proportions of ingredients shall be selected by past field experience or, in lieu of past performance, by laboratory trial mixes to produce placeability, durability, strength, and the additional properties specified.
 - b. Fly ash shall be used, but limited to not more than 25 percent by weight of portland cement.
- B. Strength: Determinations of required average strength (f'c) above specified strength shall be in accordance with ACI 318, and evaluations of compressive strength results of field concrete shall be in accordance with ACI 214.

3.3 REQUIRED CONCRETE QUALITIES

- A. General:
1. The compressive strength (f'c) of the concrete and general properties shall be as shown on the drawings. See contract drawings for location of concrete mix.
 2. Concrete subject to outdoor exposure shall be air entrained. Total air content required (air entrained and entrapped air) shall be as follows:
- | Nominal Maximum Size Coarse Aggregate | Total Air Content |
|--|-------------------|
| 3/8 inch | +2 %, -1 % |
| 3/4 inch | 7.0 percent |
| 1 inch, 1 1/2 inch | 6.0 percent |
| 2 inch | 5.5 percent |
| | 3.5 percent |
- a. Air content shall be measured by ASTM C 231.
 - b. Maximum total air content on troweled flatwork receiving a surface hardener shall be 3 percent.
 3. Concrete shall be proportioned and produced to have a slump not to exceed 4 inches, \pm 1 inch, unless noted otherwise.
 - a. Slump shall be determined by ASTM C 143.
 4. Concrete shall be adjusted to produce the required rate of hardening for varied climatic and job site conditions, as follows:
 - a. Under 50 °F Ambient Temperature: Accelerate, review required by the Construction Manager (Type E admixture in accordance with ASTM C 494).
 - b. Over 80 °F Ambient Temperature: Retard (Type D admixture in accordance with ASTM C 494).
 - c. Between 50 °F and 80 °F: Normal rate of hardening (Type A admixture in accordance with ASTM C 494).
- B. Normal Weight Concrete: Normal weight concrete shall be sand and normal weight coarse aggregate with a 145 pcf minimum density, a minimum specified 28-day compressive strength (f'c) indicated on the drawings.

- C. Lightweight Concrete: The dry unit weight of lightweight concrete shall be 115 pcf. Proportion mix to produce a split-cylinder strength factor (fct) of not less than 5.5. Limit shrinkage to 0.03 percent at 28 days. Natural sand (ASTM C 33) shall be substituted for lightweight fines. Minimum allowable compressive strength shall be 4000 psi at 28 days.

3.4 FORMWORK

- A. General: Forms shall be used to confine and shape concrete to required dimensions. Forms shall have sufficient strength to withstand forces from placement and vibration of the concrete, and sufficient rigidity to maintain specified tolerances. The use of earth cuts as forms shall not be permitted, unless approved by the Construction Manager.
 - 1. Design, engineering, and construction of the formwork shall be the responsibility of the Contractor.
 - 2. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
 - a. Interior dimensions, vertical and horizontal, for the Hot Cell, level 1, Sector 45, shall have plus or minus tolerance of 1/8 inch.
 - 3. Forms shall be designed for loads, lateral pressure, and allowable stresses in accordance with ACI 347.
 - 4. Tolerances, preparation of form surfaces, removal of forms, reshoring, and removal strength shall be in accordance with ACI 301.
- B. Coatings:
 - 1. Coat wood, plywood, fiber, and metal forms with form release agent. Wood, other than plywood, for concealed surfaces may be thoroughly wetted with water immediately before placing concrete. Do not use water in freezing weather.
 - 2. Form release agents shall be applied prior to placing of reinforcing steel. Coating material shall not be allowed to stand in puddles in the forms nor allowed to come in contact with concrete against which fresh concrete will be placed.
- C. Reuse of Forms: Forms may be reused provided strength is unimpaired during removal and surfaces are thoroughly cleaned, reconditioned to provide smooth surface, and edges are true.
- D. Provision for Work by Other Trades: Consult Architectural, Mechanical, and Electrical Drawings and other trades for requirements, and modify forms to provide for necessary items.
- E. Chamfer Strips: Chamfer exposed corners and edges using 3/4 inch by 3/4 inch chamfer strips unless otherwise noted on the drawings. Use wood, metal, polyvinyl chloride (PVC), or rubber chamfer strips fabricated to produce uniform smooth liner and tight edge joints.

3.5 REINFORCEMENT

- A. Details of reinforcement and accessories not covered in this section shall be in accordance with ACI 315. Welding shall be in accordance with AWS D1.4.
- B. Reinforcement shall be of the grade shown and shall conform to the specification listed.
- C. Concrete shall not be placed until reinforcement has been inspected. Reinforcement for each pour shall be in place to permit complete inspection.
- D. Methods of reinforcing, placing, and supports shall conform to recommended practice for placing bar supports, specifications and nomenclature by the CRSI.
- E. Reinforcement shall be free of loose rust, mill scale, earth, ice, and other coatings that destroy or reduce bond.

- F. Reinforcement shall be accurately positioned, supported, and secured against displacement by construction or concrete placement operations. Tie with annealed metal wires.
- G. Bars may be moved as necessary to avoid interference with other reinforcing steel, conduits, or embedded items. If bars are moved more than a single bar diameter, the resulting arrangement of bars shall be subject to review by the Construction Manager. Concrete cover and clearances are to be maintained.
- H. Splices not indicated on the drawings shall be Class B and as reviewed by the Construction Manager. The bar category shall be based on concrete cover and center-to-center spacing of the bars as defined in CRSI MSP.
- I. Reinforcement shall not be bent after being partially embedded in hardened concrete unless reviewed by the Construction Manager.
- J. Welding as an aid to fabrication or installation will not be permitted except as specifically shown in the Contract Documents, or as acceptable to the Construction Manager.
- K. Chemical anchoring of steel reinforcing dowels in predrilled holes shall be in strict accordance with manufacturer's recommended hole size, depth, procedures, and methods.
- L. Reinforcement shall be sheared or saw cut to fabricated lengths. Torch cutting is not permitted, unless approved by the Construction Manager.

3.6 JOINTS AND EMBEDDED ITEMS

- A. Construction Joints: Construction joints, when not shown on the drawings, shall be made and located to least impair the strength of the structure. Reinforcement shall be continued across joints unless noted otherwise.
- B. Isolation Joints and Expansion Joints: Premolded joint filler shall be placed in joints, shall be secured in place in accordance with manufacturer's recommendations, and shall be of lengths, widths, and thicknesses suitable for conditions shown or encountered. Fill top 1 inch (25 mm) between filler and slab surface flush with joint sealer.
- C. Control Joints: Control joints shall be as shown on the drawings. Control joints shall be sawed approximately equal to one-fourth the thickness of the member. Joints in permanently exposed concrete slabs shall be neatly saw cut within 12 hours of initial set and filled level with joint sealer.
- D. Dowel Supports: Dowels for slab construction joints shall be supported on an acceptable dowel basket. Dowels shall be held in correct position and alignment during the construction operation. Tie wires or bars used to hold the basket assemblies in alignment during shipping shall be cut.
- E. Waterstops: Waterstops shall be placed in accordance with manufacturer's recommendations and shall be used where shown. Splices shall be watertight and made using thermostatically controlled electric heat source.
- F. Other Embedded Items: Sleeves, inserts, anchors, and embedded items required for adjoining work or for its support shall be placed prior to concreting, positioned accurately, and supported against displacement.
 - 1. Aluminum of any type shall not be allowed in the concrete work.
 - 2. Conduits, pipes, ducts, or sleeves shall not be installed in or through concrete that are not shown on the drawings or are not reviewed and accepted by the Construction Manager.

3. Conduits, pipes, and sleeves passing through a slab, wall, or beam shall not, in the opinion of the Construction Manager, impair the strength of the construction.
4. Conduits and pipes to be placed in concrete shall be clearly shown on shop drawings with cross sections showing placement, spacing, method of support, etc., within the concrete section.
5. When conduits and pipes embedded in the concrete are acceptable to the Construction Manager, conduits and pipes embedded within a slab, wall, or beam shall satisfy the following:
 - a. They shall not be larger in outside diameter than $\frac{1}{3}$ the overall thickness of slab, wall, or beam in which they are embedded.
 - b. They shall not be placed in slabs less than 3 inches thick.
 - c. They shall not be spaced closer than three diameters on center nor have less than 2 inches clear between them.
 - d. They shall be placed in only one layer and they shall not cross over or under another pipe or conduit.
 - e. In solid slabs, conduits and piping shall be placed between top and bottom reinforcement. They shall not, in the opinion of the Construction Manager, impair significantly the strength of the construction.
 - f. Conduits or pipes shall not be placed above the welded wire fabric in slabs-on-grade or composite deck slabs.
6. Concrete cover for pipes, conduits, and fittings shall not be less than 3 inches for concrete exposed to earth or weather, nor $1\frac{1}{2}$ inches for concrete not exposed to weather or not in contact with ground.
7. Reinforcement with an area not less than 0.002 times area of concrete section shall be provided normal to conduits and piping.
8. Piping and conduit shall be so fabricated and installed that cutting, bending, or displacement of reinforcement from its proper location will not be required.
9. Concrete inserts for support of mechanical and electrical systems shall be located as shown on the drawings. Inserts shall be installed in accordance with manufacturer's recommendations.

3.7 PRODUCTION OF CONCRETE

- A. Concrete shall be batched, mixed, and transported in accordance with ASTM C 94, except that addition of water to the batch for material with insufficient slump is not permitted, unless approved by the Construction Manager. Use water-reducing admixture or super plasticizer in concrete as required for placement and workability.
 1. Plant equipment and facilities shall conform to NRMCA QC-3.

3.8 PLACING

- A. Preparation: The Contractor shall provide access for delivery and provide sufficient equipment and manpower to rapidly place concrete.
- B. Placement: Work shall be in accordance with ACI 304R.
 1. Formwork shall have been completed and snow, ice, water, and debris removed from within forms.
 2. Subgrades shall be sprinkled sufficiently to eliminate water loss from the concrete.
 3. Concrete shall not be placed on frozen ground.
 4. Before fresh concrete is placed against hardened concrete, laitance and loose or damaged materials shall be removed and surfaces dampened with water.
 5. A minimum of 48 hours shall elapse between previously placed and fresh concrete at construction joints.
 6. A minimum of two hours shall elapse after depositing concrete in columns or walls before depositing in beams, girders, column capitals, or slabs supported thereon. Beams, girders, column capitals, drop panels, haunches, and brackets shall be considered a part of floor system and shall be placed integrally therewith.

7. Depress floor slabs to depths required for installation of floor finishes, recesses, insulation, etc., as indicated or specified.
- C. Conveying: Concrete shall be handled from mixer to final deposit rapidly by methods which shall prevent segregation or loss of ingredients that maintain required quality of concrete. Unlined wood chutes are not permitted.
- D. Depositing: Concrete shall be deposited continuously. When continuous placement is not possible, construction joints shall be located as reviewed by the Construction Manager. Concrete shall be placed as nearly as possible to its final position. Avoid rehandling or flowing.
 1. Concrete shall be consolidated by vibration, spading, rodding, or forking. Work concrete around reinforcement, embedded items, and into corners. Eliminate air or stone pockets and other causes of honeycombing, pitting, or planes of weakness.
 2. Internal vibration shall have a minimum frequency of 8000 vibrations per minute with amplitude to consolidate effectively, and as follows:
 - a. Vibrators shall be operated by competent workmen.
 - b. Use of vibrators to transport concrete shall not be allowed.
 - c. Vibrators shall be inserted and withdrawn approximately every 18 inches for 5 to 15 seconds.
- E. Finish: The unformed surfaces of concrete shall have, at a minimum, a float finish, unless otherwise indicated. The finish shall be smooth and flat without aggregate shapes, honeycomb, rock pockets, etc.
 1. If roughened surfaces are required or necessary, the roughened surface shall be applied after the float finish is completed. Roughened surfaces shall have an amplitude as recommended by ACI 318.

3.9 WEATHER CONDITIONS

- A. Cold Weather: Temperature of concrete delivered at the job site shall conform to the following minimum:

Air Temperature	Concrete Temperature
30 °F to 45 °F	55 °F to 90 °F
0 °F to 30 °F	60 °F to 90 °F
Below 0 °F	65 °F to 90 °F

1. Work shall be in accordance with ACI 306R.
 2. Water heated to above 100 °F shall be combined with the aggregates before cement is added. Cement shall be not added to water or aggregates having a temperature greater than 100 °F.
 3. When the outdoor temperature is less than 40 °F, temperature of the concrete in place shall be maintained at not less than 50 °F for the required curing time.
 - a. Arrangements shall be made before placement to maintain required temperature without injury from excessive heat.
 - b. Combustion heaters shall not be used during the first 48 hours without precautions to prevent exposure of concrete and workmen to exhaust gases.
- B. Hot Weather: Temperature of concrete delivered at the job site shall not exceed 90 °F. Ingredients shall be cooled before mixing to prevent concrete temperature in excess of 90 °F.
1. Work shall be in accordance with ACI 305R.
 2. Provisions shall be made for windbreaks, shading, fog spraying, sprinkling, or wet cover when necessary.

3.10 CURING AND PROTECTION

- A. Protection: Immediately following placement, concrete shall be protected from premature drying, hot and cold temperatures, rain, flowing water, and mechanical injury.
- B. Curing: Materials and method of curing shall be reviewed by the Construction Manager. Final curing shall continue for not less than seven days.
 - 1. Acceptable methods shall be limited to liquid membrane forming compounds and sheet material.
 - a. Applications of waterproof sheet material shall conform to ASTM C 171.
 - b. For special flooring finishes, cure concrete in accordance with manufacturer's recommendations.
 - c. Concrete to receive chemical hardener shall be moist cured or liquid membrane compatible with hardener.

3.11 REPAIR OF SURFACE DEFECTS

- A. Concrete work which has not been installed as indicated on the drawings or which is out of line or level or flatness or has defective surfaces shall be considered not conforming with intent of these specifications and shall be removed, unless the Construction Manager grants permission to patch defective areas. Permission to patch any area shall not be considered a waiver of the Construction Manager's right to require complete removal of defective work if patching does not satisfactorily restore quality of the work and appearance of surface.
 - 1. Immediately after stripping forms, inspect surfaces, cut ties, remove fins or projections, fill tie holes, and patch honeycombing.
 - 2. Patching shall be done before concrete is thoroughly dry. Patching shall be with same materials and proportions as concrete, except coarse aggregate shall be omitted. On exposed work, white portland cement shall be substituted for a part of the gray cement in order to produce a color matching that of the surrounding concrete, as determined by a trial patch. Dampen area to be patched. Add only enough water to permit working mortar into defects, strike off, and allow to set. Rub with carborundum to bring surface to same texture, color, etc., as adjacent surfaces.

3.12 FINISHING OF FORMED SURFACES

- A. General: After removal of forms, concrete surfaces shall be given one or more of the finishes specified below in locations indicated on the drawings or hereinafter specified.
- B. As-Cast Finishes:
 - 1. Where shown or specified to receive a rough form finish, surfaces shall be true to line and level. Tie holes and defects shall be patched and fins exceeding 1/4 inch (6 mm) rubbed down. Otherwise surfaces shall be left with texture imparted by forms. Exterior and interior surfaces not exposed to view shall have rough form finish.
 - 2. Where shown or specified to receive a smooth form finish, the form facing material shall produce a smooth, hard, uniform texture on the concrete. It may be plywood, tempered concrete-form grade hardboard, metal, plastic, paper, or other acceptable material capable of producing the desired finish. Material with raised grain, torn surfaces, worn edges, patches, dents, or other defects which shall impair the texture of the concrete surface shall not be used. Tie holes and defects shall be patched. Fins shall be completely removed. Interior exposed-to-view vertical surfaces and interior exposed-to-view overhead surfaces shall have smooth form finish. Exterior wall surfaces to receive waterproofing or dampproofing shall have smooth form finish.
- C. Rubbed Finishes: Where shown or specified to receive a smooth rubbed finish, produce finish on fresh hardened concrete. Necessary patching shall be done immediately after removal of forms and rubbing shall be completed within a day. Wet surfaces with water and rub with carborundum until a uniform color and texture are produced. No cement grout or slush shall be

used. Exterior and interior surfaces exposed to view shall have smooth rubbed finish as noted on the drawings.

3.13 SLABS

- A. General: Work required below slabs on ground shall be completed, checked, and tested. Vapor barrier shall not be used on building retaining wall slabs/footings.
1. The subgrade shall be well drained and of adequate and uniform loadbearing nature. The in-place density of the subgrade soils shall be at least the minimum required.
 2. Granular base course, where shown, shall be at required level and well compacted.
 3. Vapor barrier shall be furnished in rolls not less than 10 feet wide and as long as practicable. The material shall be placed in the maximum widths and lengths practicable so as to eliminate joints wherever possible. Where joints are necessary, the material shall be lapped not less than 6 inches for side and end laps and sealed with acceptable adhesive. Torn, punctured, or damaged vapor barrier shall be patched. Patch shall be lapped 12 inches and sealed. Concrete shall be placed in a manner to preclude damage to the vapor barrier material. Turn up vapor barrier at walls.
 4. Install perimeter insulation where indicated on the drawings. At underside of floor slabs, place insulation over vapor barrier. Install and secure insulation in accordance with Section 07210 - Building Insulation.
 5. Install construction joints, column isolation joints, and embedded items as indicated or specified.
 6. Deposit concrete in final position and in full layer.
 7. Consolidate thoroughly with vibrating screeds, roller pipe screeds, or with expanded metal tampers. Concrete shall be as dry as practicable.
 8. Concrete shall be struck off at required elevations allowing for finishes, depressions, etc., indicated or specified.
 9. Where drains occur, entire area served by each drain shall pitch uniformly to drain.
- B. Monolithic Floor Slabs:
1. Scratch Finish: Apply scratch finish to monolithic slab surfaces to receive mortar setting beds for tile, portland cement terrazzo, and other bonded applied cementitious finish flooring material, and as otherwise indicated.
 - a. After placing slabs, plane surface to tolerances for floor flatness (Ff) of 15 and floor levelness (FI) of 13. Slope surfaces uniformly to drains where required. After leveling, roughen surface before final set with stiff brushes, brooms, or rakes.
 2. Float Finish: Apply float finish to monolithic slab surfaces to receive trowel finish and other finishes as hereinafter specified. Slab surfaces shall be covered with membrane and as otherwise indicated.
 - a. After screeding, consolidating, and leveling concrete slabs, do not work surface until ready for floating. Begin floating, using float blades or float shoes only, when surface water has disappeared, when concrete has stiffened sufficiently to permit operation of power-driven floats, or both. Consolidate surface with power-driven floats or by hand-floating if area is small or inaccessible to power units. Check and level surface plane to tolerances of Ff 18 and FI 15. Cut down high spots and fill low spots. Uniformly slope surfaces to drains. Immediately after leveling, refloat surface to a uniform, smooth, granular texture.
 3. Trowel Finish: Apply trowel finish to monolithic slab surfaces to be exposed to view and slab surfaces to be covered with resilient flooring, carpet, ceramic tile, or thin film finish coating systems.
 - a. After floating, begin first trowel finish operation using a power-driven trowel. Begin final troweling when surface produces a ringing sound as trowel is moved over surface. Consolidate concrete surface by final hand-troweling operation, free of trowel marks, uniform in texture and appearance, and with surface leveled to tolerances of Ff 20 and FI 17. The minimum local values (MLV) shall be Ff 18 and FI 15. Area to be considered for a MLV shall be each half of a bay and each

- bay as bounded by column grid lines and/or half-column grid lines. Grind smooth surface defects that would telegraph through applied floor covering system.
4. Trowel and Fine Broom Finish: Where ceramic tile is to be installed with thin-set mortar, apply trowel finish as specified, then immediately follow with slightly scarifying surface by fine brooming.
 5. Nonslip Broom Finish: Apply nonslip broom finish to exterior concrete platforms, steps, and ramps, and elsewhere as indicated.
 - a. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber-bristle broom perpendicular to main traffic route. Coordinate required final finish with the Construction Manager before application.
 6. Nonslip Aggregate Finish: Apply nonslip aggregate finish to concrete stair treads, platforms, ramps, sloped walks, and elsewhere as indicated.
 - a. After completion of float finishing and before starting trowel finish, uniformly spread 25 pounds of dampened nonslip aggregate per 100 square feet of surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface. After broadcasting and tamping, apply trowel finishing as herein specified.
 - b. After curing, lightly work surface with a steel wire brush, or an abrasive stone, and water to expose nonslip aggregate.
 7. Finish surface tolerances shall be measured within 24 hours according to ASTM E 1155E for a randomly trafficked floor surface.
- C. Concrete Slabs: Provide concrete slab over steel form. Steel deck units shall be free of oil, grease, and water. Place concrete in full thickness, strike off, consolidate, and finish as herein specified for finishes indicated.
- D. Surface Treatment: Trowel finished interior concrete floors which are to remain exposed shall receive two coats of curing material. First coat shall be applied after final finishing and second coat shall be applied when all trades are completed and structure is ready for occupancy.

3.14 MISCELLANEOUS CONCRETE ITEMS

- A. Penetrations: Shafts and sleeves through floors shall be properly fire-stopped and smoke-stopped at each floor with concrete fill maintaining required ratings. Carefully point around pipe sleeves where carried through concrete to present a neat finish.
- B. Grout: Grout for elevator sills and similar items shall be composed of portland cement and sand, mixed to a plastic consistency.
- C. Equipment Bases, Curbs, and Foundations: Provide machine and equipment bases, curbs, and foundations, as shown on Architectural, Mechanical, and Electrical Drawings. Set anchor bolts for machines and equipment to template at correct elevations, complying with certified diagrams or templates of manufacturer furnishing machines and equipment.
- D. Steel Pan Stairs: Provide concrete fill for steel pan stair treads and landings and associated items. Concrete fill shall be normal weight and have a maximum size aggregate of 3/8 inch. Cast-in safety inserts and accessories as shown on the drawings. Screed, tamp, and finish concrete surfaces as scheduled.

3.15 FIELD QUALITY CONTROL

- A. The Contractor shall engage an independent Inspection and Testing Agency to perform shop and field inspections and tests specified herein, and prepare test reports. The extent and description of field test requirements shall be as specified hereinafter.
 1. Inspection and testing agencies shall meet the requirements of ASTM E 329.
 2. Sampling and testing for quality control during placement of concrete shall include, but shall not be limited to, the following:

- a. Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94.
 - b. Slump: ASTM C 143; one test at point of discharge for each day's pour of each type of concrete; additional tests when concrete consistency seems to have changed.
 - c. Air Content: ASTM C 173, volumetric method for lightweight or normal weight concrete; ASTM C 231 pressure method for normal weight concrete; one for each day's pour of each type of air-entrained concrete.
 - d. Concrete Temperature: Test hourly when air temperature is 40 °F and below, and when 80 °F and above; and each time a set of compression test specimens made.
 - e. Compression Test Specimen: ASTM C 31; one set of six standard cylinders for each compressive strength test, unless otherwise directed. Mold and store cylinder for laboratory-cured test specimens except when field cure test specimens are required. When frequency of testing shall provide less than five strength tests for a given class of concrete, conduct testing from at least five randomly selected batches or from each batch if fewer than five are used.
 - f. Compressive Strength Tests: ASTM C 39; one set of each day's pour exceeding 5 cubic yards plus additional sets for each 50 cubic yards over and above the first 25 cubic yards of each concrete class placed in any one day; two specimen tested at seven days, two specimens tested at 28 days, and two specimen retained in reserve for later testing if required.
 - g. Finish surface tolerances shall be measured within 24 hours according to ASTM E 1155E
3. Test results shall be reported in writing to the Construction Manager within 24 hours after tests. Reports of compressive strength tests shall contain the project identification name and number, date of concrete placement, name of concrete testing service, concrete type and class, location of concrete batch in structure, design compressive strength at 28 days, concrete mix proportions and materials, and compressive breaking strength and type of break for both seven day tests and 28 day tests.
 4. Impact hammer, sonoscope, or other nondestructive device may be permitted, but shall not be used as the sole basis for acceptance or rejection.
 5. The testing service shall make additional tests of in-place concrete when test results indicate specified concrete strengths and other characteristics have not been attained in the structure, or when early strengths may be required, as directed by the Construction Manager. Testing service may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed. The Contractor shall pay for such tests when unacceptable concrete is verified.
- B. The Contractor shall provide and pay for the necessary testing services of the following:
1. Qualification of proposed materials and the establishment of mix designs in accordance with ACI 318.
 2. Other testing services needed or required by the Contractor.
- C. To facilitate testing and inspection, the Contractor shall:
1. Furnish necessary labor to assist the Inspection and Testing Agency in obtaining and handling samples at the job site.
 2. Advise the Inspection and Testing Agency in advance of operations to allow for the assignment of testing personnel and testing.
 3. Provide and maintain for the use of the Inspection and Testing Agency, adequate facilities for proper curing of concrete test specimens on the Project site in accordance with ASTM C 31.

END OF SECTION 03300